Oxychlorine species on Mars: Implications from Gale Crater Samples

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Evidence of oxychlorine species such as perchlorates or chlorates have been detected in nearly every acquired sample analyzed on the surface of Mars. Perchlorates were first discovered by the Wet Chemistry Laboratory (WCL) instrument on the Phoenix lander in 2008. The Sample Analysis at Mars (SAM) instrument on the Mars Science Laboratory (MSL) has analyzed twelve samples from Gale Crater (as of July 2016), nine drilled samples and three scooped samples. After delivery to SAM, samples are heated to ~850 °C and evolved gases are measured by a quadrupole mass spectrometer.

In all samples analyzed to date (with one exception), SAM has detected a low temperature (<600 °C) O_2 release and an HCl release from ~350-850 °C consistent with the thermal decomposition of an oxychlorine compound. The O_2 release temperature varies with sample, likely caused by different cations (e.g. Mg^{2+}, Ca^{2+}, or Na^{+}) or the presence of minerals which have a catalytic effect on oxychlorine decomposition. In the oxychlorine-containing samples, perchlorate abundances range from 0.06 ± 0.03 to 1.15 ± 0.5 wt% Cl_2O_7 equivalent. Assuming perchlorate to be the anion, oxychlorine species account for 5-40% of the total Cl in the sample, measured by the Alpha Particle X-ray Spectrometer on MSL.

The John Klein (JK) and Cumberland (CB) samples are particularly interesting because despite being acquired within a few meters of each other in the Sheepbed mudstone, CB contained ~1.2 wt% Cl_2O_7 equivalent and JK had ~0.1 wt%. One difference between the two samples is that JK has a large number of veins visible in the drill hole wall, indicating that the sample was altered after deposition and lithification. This implies that oxychlorine formation occurred in the ancient martian past and that removal (and redeposition) has subsequently taken place.